



**RUSSIAN URANIUM ENRICHMENT INDUSTRY
STATE & PROSPECTS OF DEVELOPMENT**

**International Business Relations, LLC (IBR™)
Department of Nuclear Power Engineering & Nuclear Fuel Cycle**

Moscow, 2016

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- *Knowledge of the tools for economic and investment analysis of nuclear technologies;*
- *Experience in successful management of “nuclear” projects.*

IBR™ strives for expansion and intensification of cooperation with its constant clients and welcomes collaboration with new clients in the interests of further improvement of safety and efficiency of nuclear technologies.

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**Russian Uranium Enrichment Industry.
State & Prospects of Development. 2016**

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EXECUTIVE SUMMARY

- ❖ On June 8, 2006 the RF President Vladimir Putin approved the “Program of the RF Nuclear Industry Development” aimed at further development of the Russian nuclear complex. The reforms in the Russian nuclear complex based on a new legislation were defined as one of the Program top-priority objectives.

Largely, the new “nuclear” legal base was provided within 2006-2008. The issues of principal importance in the new legal base are:

- Potentiality granted to the Russian civil nuclear complex enterprises to function as joint stock companies;
- Opportunity granted to the joint stock companies to own and manage “power” grade nuclear materials and nuclear facilities.

By the end of 2009, privatization (incorporation to joint-stock companies) of the federal state unitary enterprises within civil sector of the Russian nuclear complex planned for privatization was largely completed.

The period of 2006-2011 in corporate development of the Russian nuclear complex nuclear fuel division (uranium mining, conversion, enrichment, nuclear fuel and FA fabrication) is characterized by a string of ill-conceived administrative decisions bringing about several attempts of reforms in the nuclear fuel division corporate structure. A next in turn stage of the Russian nuclear complex nuclear fuel division reforming commenced late in 2009 after decision-making about concentrating the assets in uranium conversion and enrichment, as well as nuclear fuel and FA fabrication, within a single corporate structure set up on the basis of JSC TVEL. By early 2011, actual buildup of the JSC TVEL corporate structure was completed.

Reforms in the Russian nuclear complex nuclear fuel division concerned research and production enterprises, besides the division corporate structure, include:

- Reforms of research and production enterprises internal organizational structures;
- Reforms of research and production enterprises internal business relations,

for improving the economic efficiency of the fuel division functioning as such.

Active measures aimed at reduction of management and production costs (inclusive of non-core processes divestiture, transfer of some services and subdivisions to outsourcing, introduction of programs of “SC Rosatom thrifty processes”) are taken. The main costs saving measures (mainly connected with enterprises’ restructuring) were implemented in the period of 2010-2012. Enterprises’ restructuring associated with the withdrawal of non-core assets was largely completed to 2012. The measures directed to the costs saving are developing and implementing every year.

- ❖ The Strategy of the SC Rosatom Fuel Division¹ Development was adopted on December 6, 2011. The Strategy of the SC Rosatom Fuel Division Development was updated in mid-2013.

On January 28, 2014, JSC Techsnabexport’s Strategy of Development through 2030 was approved.

On December 9, 2014, SC Rosatom Strategy Council approved the following documents:

- Strategy of the Fuel Company TVEL Development through 2030 (Strategy);
- Business Plan for Fuel Company TVEL for 2015 thru 2019.

The Strategy of the Fuel Company TVEL Development through 2030 and enrichment enterprises medium-term development programs provide for further upgrading of the Russian uranium enrichment industry and growth of its installed/nominal capacity. In compliance with Strategy of the Fuel Company TVEL Development through 2030, Fuel Company TVEL and Techsnabexport would acquire 42% of the global market of commercial uranium enrichment services (commercial SWU) by 2030 of which:

¹ Originally, SC Rosatom Fuel Division was consisted of JSC TVEL and JSC Techsnabexport. At the end of 2013, JSC Techsnabexport was excluded from SC Rosatom Fuel Division.

- ✓ 20% would fall on TVEL;
- ✓ 22%, on Techsnabexport.

In accordance with the Strategy of the Fuel Company TVEL Development through 2030, SC Rosatom / JSC TVEL plan, apart from taking up 42% of the commercial SWU market, to develop an additional uranium enrichment capacity for the economically effective utilization in the following areas:

- Underfeeding;
- Enrichment of Accumulated Depleted Uranium Quantities.

As shown in the IBR™ analysis, with regard for the three SWU utilization areas, SC Rosatom / JSC TVEL plan the following development dynamics for the Russian uranium enrichment facilities (rated capacity):

- ✓ 2015 ~ 27.0 million SWU (2014 ~ 28.2 million SWU);
- ✓ 2025 ~ 36.4 million SWU;
- ✓ 2030 ~ 40.1 million SWU.

- ❖ At this point in Russia GC of four generations are in commercial operation (6th, 7th, 8th and 9th). Modern technology of uranium enrichment is based on supercritical GC of the 9th generation Three Russian design bureaus were engaged in the development and testing of the 9th generation supercritical GC. Late in 2008, the choice was made in favor of the 9th generation GC design developed by CJSC “OKB – Nizhny Novgorod” (model “K4110U”). The height of the new GC rotor is approximately 310 mm more than that of the 8th generation GC rotor, and it makes up ~ 840 mm. The Trial Board on the 9th generation GC acceptance completed its activities at UECC on March 28, 2012. Based on the inspection results the Trial Board recommended the 9th generation GC for commercial manufacture. JSC Kovrov Mechanical Plant shipped the first industrial batch of the 9th generation GC to the ECP address late in May 2012. The first block/unit fitted out with the 9th generation GC was made operational at ECP by the end of 2012. Four blocks/units fitted out with the 9th generation GC are in operation at the Russian enrichment enterprises as of the end of 2015.

In 2014, TVEL started the pilot-industrial operation of gas centrifuge (GC) K379/K379N of generation 9+ with a composite rotor (two subcritical rotors connected by a bellows) developed at the Nizhny Novgorod Pilot Design Bureau. It is planned that commercial production of those GCs would be launched in early 2017. The first block/unit with the 9+ generation GCs would be commissioned in late 2017.

In late 2014, TVEL made a decision to terminate the work at the 10th generation GCs and focus on the development of the “high” gas centrifuge of the 11-th generation (TC-21 type of the ETC Company). The design bureaus were requested to start the pilot production of the 11-th generation GCs in 2018 and commercial operation, in 2020.

Allegedly, in 2015 JSC TVEL decided to reduce considerably the R&D on GC-11 due to the absence of obvious economic advantages in the switchover from the GC-9+ technology to the GC-11 technology. Besides:

- The GC-11 manufacturing and assembly technology is much more complex than the GC-9+ technology;
- The reliability of GC-11 is lower than that of GC-9+.

The R&D for 6-th generation GC's capacity increase by increase of GC rotor frequency rotation was started at ECP in 2015.

- ❖ Analysis of the status and development outlooks of the Russian separation-sublimate complex, forecast of the global demand for SWU and analysis of the plans of foreign companies in increasing the installed capacity of their enrichment enterprises permit IBR™ to make the following prediction of the rate of the Russian enrichment industry development in terms of nominal capacity:

- 2015 – 27.0 Mln. SWU (2014 ~ 28.2 million SWU);
- 2020 – 30.4 Mln. SWU;
- 2030 – 35.6 Mln. SWU;
- 2035 – 35.5 Mln. SWU.

The following conclusions underlie the IBR™ prediction of dynamics of the Russian enrichment industry development in the period of 2015-2035:

- Under the present international political-and-economic situation, future activity of SC Rosatom looks rather uncertain;
 - It seems that economic recession, which started in Russia in mid-2014, would last for long. As a result, Russia's capabilities to finance NPPs construction abroad to Russian designs would narrow greatly, which would lead to sagging demand for Russian uranium enrichment products against the pre-crisis forecasts;
 - The drop of prices for fossil energy sources such as oil & gas would preserve at least in the midterm, which would decelerate the rate of nuclear power development the world over;
 - The Russian enrichment industry is provided with competitive technologies for at least in the next 10 years;
 - The Russian industry engaged in manufacture of equipment for the enrichment industry can provide for the needs in the equipment;
 - In the period 2016-2035 the Russian enrichment industry will basically have most of the necessary investment resources for being upgraded;
 - The 6-th generation GC operational life-time was extended from 30 to 40 years in 2014;
 - The commercial production of GC-9+ will start in 2017. The GC-9+ will be the main centrifuge until 2035;
 - The SWU price drop since 2010 has been due to a number of causes, the major of which are:
 - ✓ A slowdown in the global power development rates;
 - ✓ Oversupply of natural uranium in the market;
 - ✓ Switchover to effective gas centrifuge technologies by a number of companies with a potential for new uranium enrichment facilities to be rapidly put into operation.
 - The IBR™ SPOT² & LT³ SWU prices are likely to stabilize at a level of \$ 60 to \$ 65 per SWU for some times. A substantial growth in the SWU price will be caused by a growth in the natural uranium price.
- ❖ As before, the Russian uranium enrichment industry remains the most economically efficient, even if compared with the best foreign companies (URENCO). In many ways, it was stipulated by the sharp drop in the ruble rate against the \$ and €, that took place in 2014 - 2015. The specific investments in the development of enrichment industry (new construction, upgrading) and the specific operating costs in the SWU production are much lower in Russian industry, as compared to URENCO and AREVA.
- ❖ Export dynamics of the Russian uranium conversion and enrichment industry (LEU; uranium conversion and enrichment services)⁴:
- 2006 year - \$ 1,954 Mln;
 - 2007 year - \$ 2,339 Mln;
 - 2008 year - \$ 3,059 Mln;
 - 2009 year - \$ 3,048 Mln;
 - 2010 year - \$ 3,490 Mln;
 - 2011 year - \$ 3,388 Mln;
 - 2012 year - \$ 3,219 Mln;
 - 2013 year - \$ 3,046 Mln;
 - 2014 year - \$ 2,200 Mln.
 - 2015 year - \$ 2,700 Mln.

² The IBR™ SWU Price (Spot) considers spot offers for deliveries (one-time delivery usually) up to twelve months forward for other than Russian-origin SWU.

³ The IBR™ LT SWU Price (Long-Term) reflects base-escalated long-term offers for multi-annual deliveries to occur after a year following contract execution (signed date).

⁴ Excluding exports of LEU in the composition of the fuel pellets and fuel assemblies by JSC TVEL.

- ❖ The construction of the 4th phase of uranium enrichment plant in China based on the 6th generation GC is completed in the middle of 2011 year. The available capacity of all the four phases of the CNEIC Co. uranium enrichment plant in China amounted to ~ 1.54 Mln. SWU/year by mid-2011 (~ 460 thousand 6th generation GC). The plant's 3-years warranty operation period was completed in 2014. Continued cooperation between Russia and China on the construction of new plants in China based on Russian technology is unlikely possible, because CNEIC developed the own technology and established its own production of the gas centrifuge equipment. However, JSC TVEL continues to consider the option of a new uranium enrichment plant construction in China based on the export GC of generation 8. The negotiations on the new plant construction were begun in 2011 and have been continued to date.
- ❖ The RF President Vladimir Putin authorized selling of a shareholding (25% + 1 share) in JSC "Ural Electrochemical Combine" to the Russian–Kazakh joint enterprise CJSC "Uranium Enrichment Center" (CJSC "UEC"). The relevant regulation No. 258-rp was signed on June 29, 2013. The document permits open joint stock company "Incorporated Company "Separation-Sublimate Complex" (a JSC TVEL subsidiary) to carve-out 10 Bln. 446 Mln. 261 thous. 17 registered share of common stock in JSC "UECC" in its possession to CJSC "UEC" ownership.

The transaction on the assets acquisition in the JSC "UECC" authorized capital, i.e. 25% plus 1 share, by the Russian–Kazakh joint enterprise CJSC "UEC" was bought in on September 27, 2013. JSC TVEL earned 17,278 Bln. roubles (~ \$ 556 Mln.) as a result of the transaction.

The CJSC "UEC" sales volume was:

- ✓ 2013 ~ 0.3 Mln. SWU;
- ✓ 2014 ~ 5.0 Mln. SWU;
- ✓ 2015 ~ 5.0 Mln. SWU.